

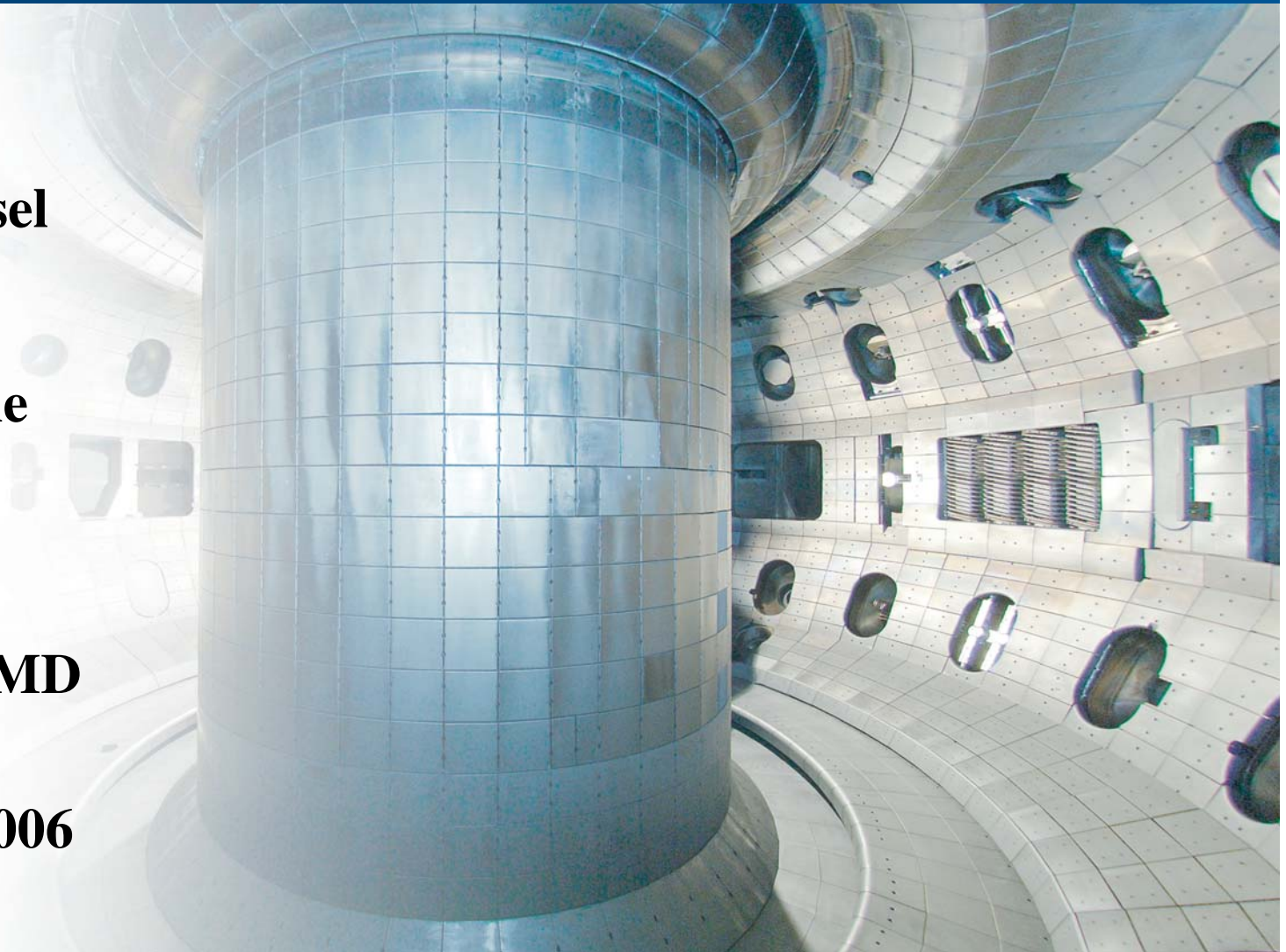
Collaborative Technologies for Distributed FES

**By
David P. Schissel**

Presented at the

**U.S. DOE
Headquarters
Germantown, MD**

November 7, 2006



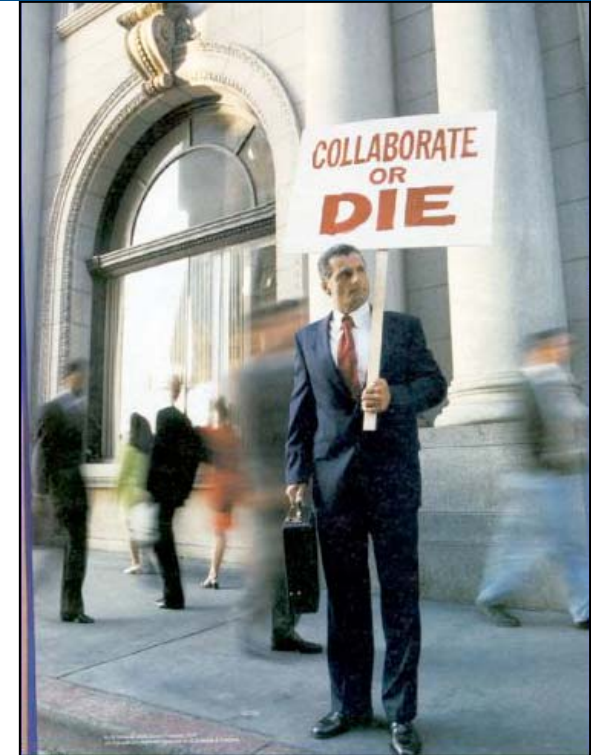
Acknowledgment

- **The National Fusion Collaboratory Project Team Members (Distributed)**
 - C-Mod (MIT), DIII-D (GA), NSTX (PPPL)
 - Argonne National Lab, Lawrence Berkley Lab, Princeton University, University of Utah
- **The Staff of the DIII-D National Fusion Facility**
- **Work is supported by the USDOE Department of Energy**
 - SciDAC: Office of Advanced Scientific Computing Research
 - Fusion Research: Office of Fusion Energy Sciences

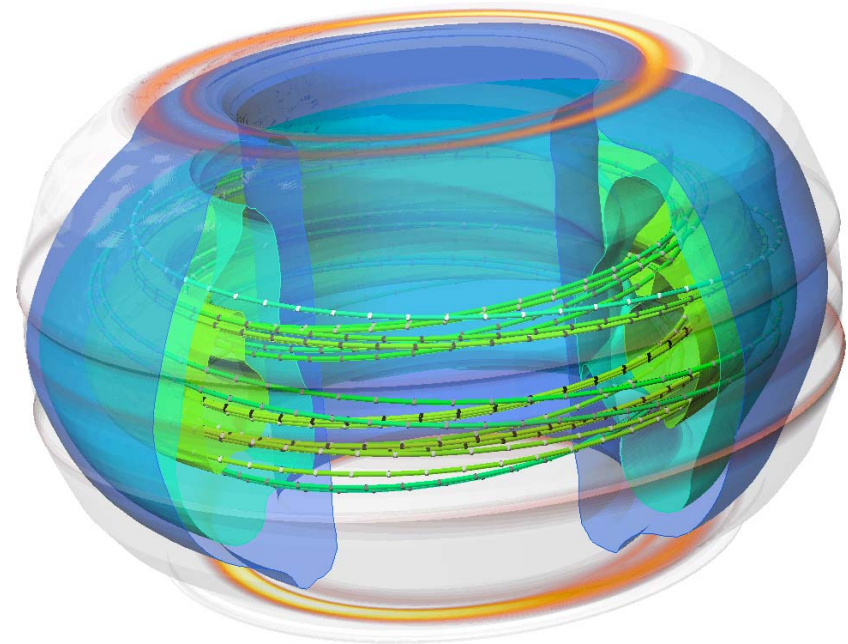
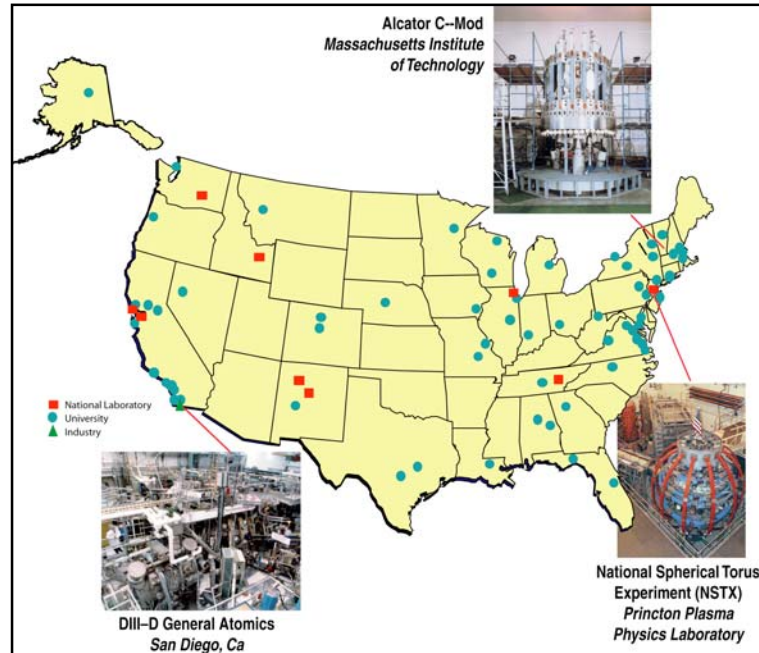


Presentation's Key Points: Fusion Energy Perspective

- **International collaboration is our future:**
ITER will be the most important facility for 20-25 years
 - For the US to get the most from the project, we must be prepared to exploit the machine remotely
- **Remote collaborations on domestic facilities will continue to be important**
 - Preparation and support for ITER
- **National Fusion Collaboratory Project (FusionGrid)**
 - Scientists using NFC developed tools to enhance current collaborations
 - Remote collaboration: session leadership becomes routine
- **Extend our existing tools to meet future needs**
 - Functionality, international FES, other SC programs (e.g. HEP)
 - Prototype tools and methodology for ITER



U.S. Magnetic Fusion: Three Large Experimental Facilities and a Vibrant Theoretical Community



- 3 Large Experimental Facilities
 - ~\$1B replacement cost
- Numerous theoretical groups
 - High-performance computing
- 67 U.S. fusion research sites
 - Over 1500 scientists
- Efficient collaboration is required
 - Geographically diverse teams

Fusion Science Today is Worldwide Team Sport



- 90 institutions participate
- 425 active users
- 317 scientific authors
- Students and faculty from
 - 65 universities
 - 28 states

Active Collaborations 2004

US Labs

ANL (Argonne, IL)
LANL (Los Alamos, NM)
LBNL (Berkeley, CA)
LLNL (Livermore, CA)
ORNL (Oak Ridge, TN)
PPPL (Princeton, NJ)
SNL (Sandia, NM)

Industries

Calabasas Creek (CA)
CompX (Del Mar, CA)
CPI (Palo Alto, CA)
Digital Finetec (Ventura, CA)
DRS (Dallas, TX)
DTI (Bedford, MA)
FAR Tech (San Diego, CA)
IOS (Torrance, CA)
Lodestar (Boulder, CO)
SAIC (La Jolla, CA)
Spinner (Germany)
Tech-X (Boulder, CO)
Thermacore (Lancaster, PA)
Tomlab (Willow Creek, CA)
TSI Research (Solana Beach, CA)

US Universities

Auburn (Auburn, Alabama)
Colorado School of Mines (Golden, CO)
Columbia (New York, NY)
Georgia Tech (Atlanta, GA)
Hampton (Hampton, VA)
Lehigh (Bethlehem, PA)
Maryland (College Park, MD)
Mesa College (San Diego, CA)
MIT (Boston, MA)
Palomar (San Marcos, CA)
New York U. (New York, NY)
SDSU (San Diego, CA)
Texas (Austin, TX)
UCB (Berkeley, CA)
UCI (Irvine, CA)
UCLA (Los Angeles, CA)
UCSD (San Diego, CA)
U. New Mexico (Albuquerque, NM)
U. Rochester (NY)
U. Utah (Salt Lake City, UT)
Washington (Seattle, WA)
Wisconsin (Madison, WI)

Russia

Ioffe (St. Petersburg)
Keldysh (Udmurtia, Moscow)
Kurchatov (Moscow)
Moscow State (Moscow)
St. Petersburg State Poly (St. Petersburg)
Trinity (Troitsk)
Inst. of Applied Physics (Nizhny Novgorod)

European Community

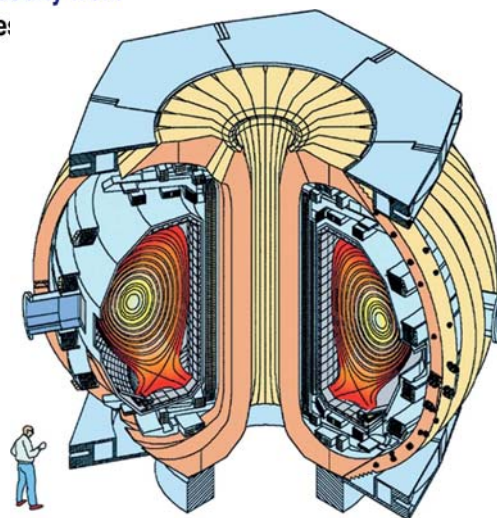
Cadarache (St. Paul-lez, Durance, France)
Chalmers U. (Göteborg, Sweden)
CFN-IST (Lisbon, Portugal)
CIEMAT (Madrid, Spain)
Consorzio RFX (Padua, Italy)
Culham (Culham, Oxfordshire, England)
EFDA-NET (Garching, Germany)
Frascati (Frascati, Lazio, Italy)
FOM (Utrecht, The Netherlands)
Helsinki U. (Helsinki, Finland)
IFP-CndR (Italy)
IPP (Garching, Greifswald, Germany)
ITER (Garching, Germany)
JET-EFDA (Oxfordshire, England)
KFA (Jülich, Germany)
Kharkov IPT, (Ukraine)
Lausanne (Lausanne, Switzerland)
IPP (Greifswald, Germany)
RFX (Padova, Italy)
U. Dusseldorf (Germany)
U. Naples (Italy)
U. Padova (Italy)
U. Strathclyde (Glasgow, Scotland)

Japan

JAERI (Naka, Ibaraki-ken, Japan)
JT-60U
JFT-2M
Tsukuba University (Tsukuba, Japan)
NIFS (Toki, Gifu-ken, Japan)
LHD

Other International

Australia National U. (Canberra, AU)
ASIPP (Hefei, China)
Dong Hau U. (Taiwan)
KBSI (Daegon, S. Korea)
KAERI (Daegon, S. Korea)
Nat. Nucl. Ctr. (Kurchatov City, Kazakhstan)
Pohang U. (S. Korea)
Seoul Nat. U. (S. Korea)
SWIP (Chengdu, China)
U. Alberta (Alberta, Canada)
U. of Kiel (Kiel, Germany)
U. Toronto (Toronto, Canada)

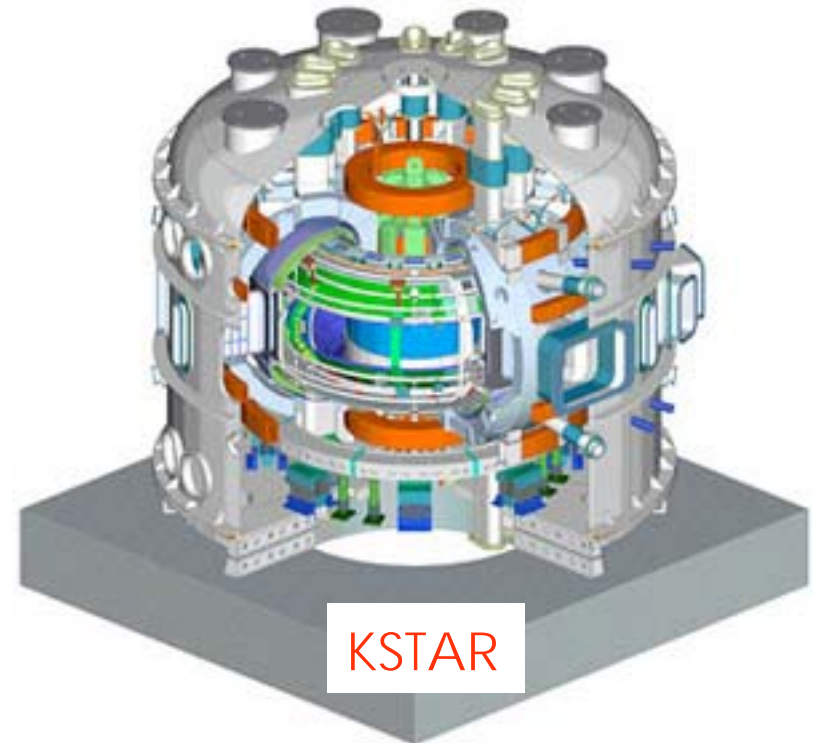


**An Example From
The DIII-D National
Fusion Facility in
San Diego**

Fusion Science Today is Worldwide Team Sport

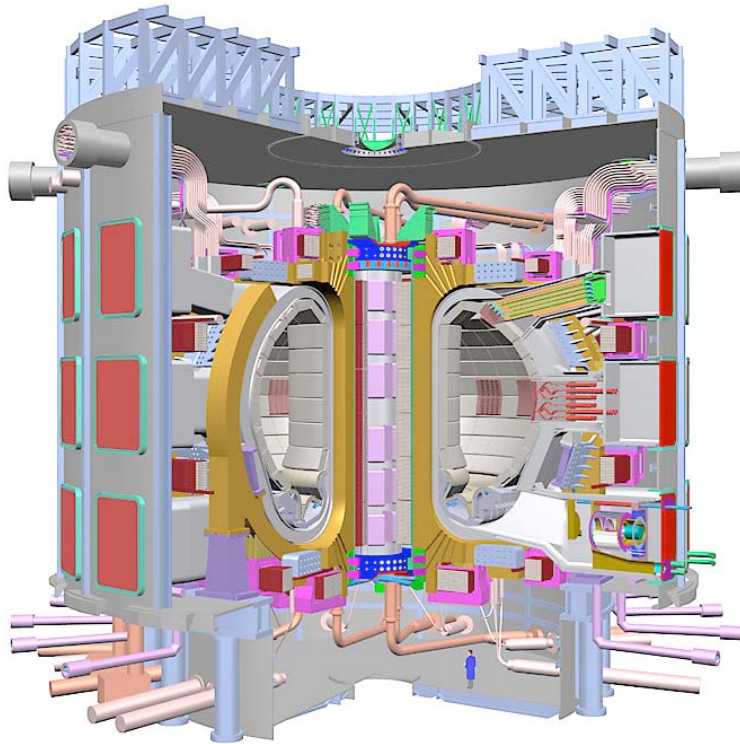


Two New Machines in Asia: China and South Korea



- EAST had first plasma last month, KSTAR under construction
 - Both have significant U.S. collaboration
- Excellent test beds for distributed science on ITER

Next Fusion Device is ITER to be Built in France



- China, Europe, India, Japan, South Korea, Russia, United States
- ~5B total construction cost
 - First plasma ~10 years
- Burning plasma experiment
 - Demonstrate physics viability

First on our list is fusion. The prospect of limitless source of clean energy for the world leads with our commitment to join the international fusion energy experiment known as ITER.

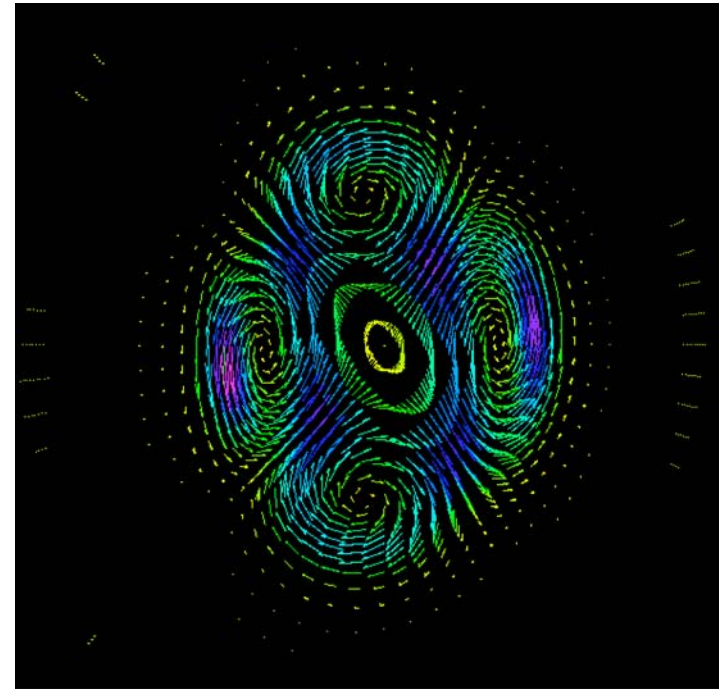
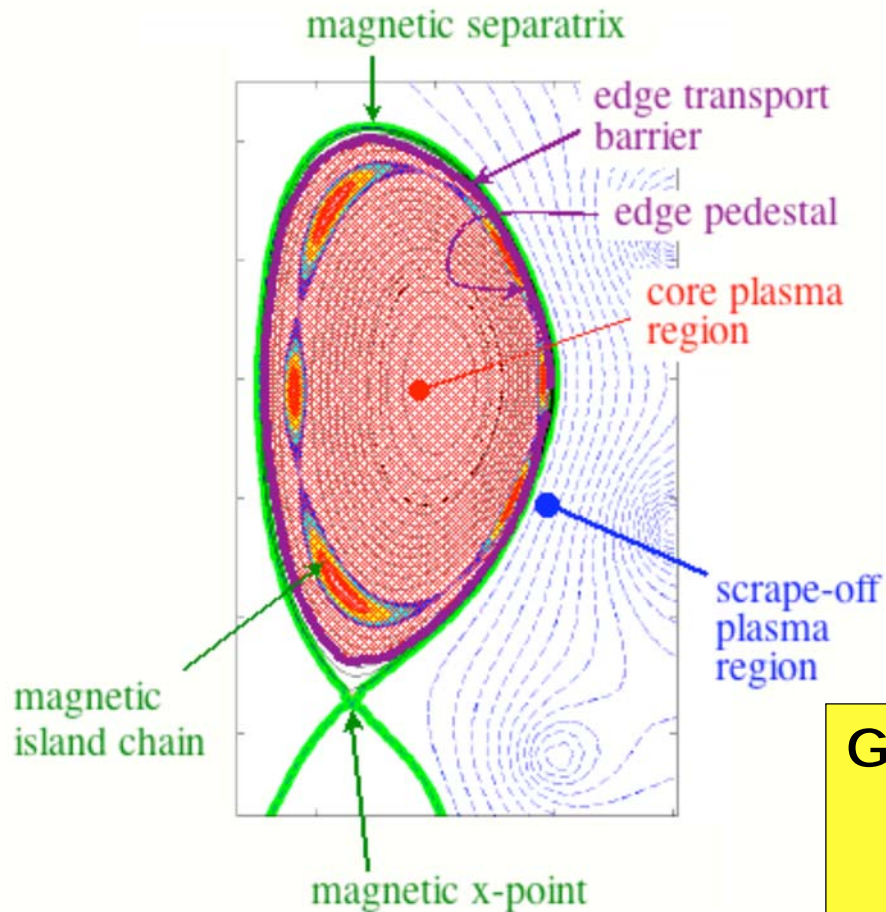
– Secretary of Energy Spencer Abraham, November 10, 2003

Introducing the Department's 20-year plan for building the scientific facilities of the future.

Fusion Research Presents Many Challenges

- **Development of physical models for plasma stability and transport**
 - Vast range in space and time which can span over 10 decades
 - 3D motion, extreme anisotropy, free energy driven turbulence
- **Design large experiments**
 - 3D coupling of electromagnetics, structures, heat transfer, neutronics
- **Development of complex diagnostics**
- **Development of plasma heating and fueling methods**
- **Acquisition, analysis, display and interpretation of large quantities of experimental data**
- **All of these are computationally intensive**

Fusion Simulation Project (FSP): Integrated Simulation and Optimization of Fusion Systems



Goals of joint OFES & OASCR Program:

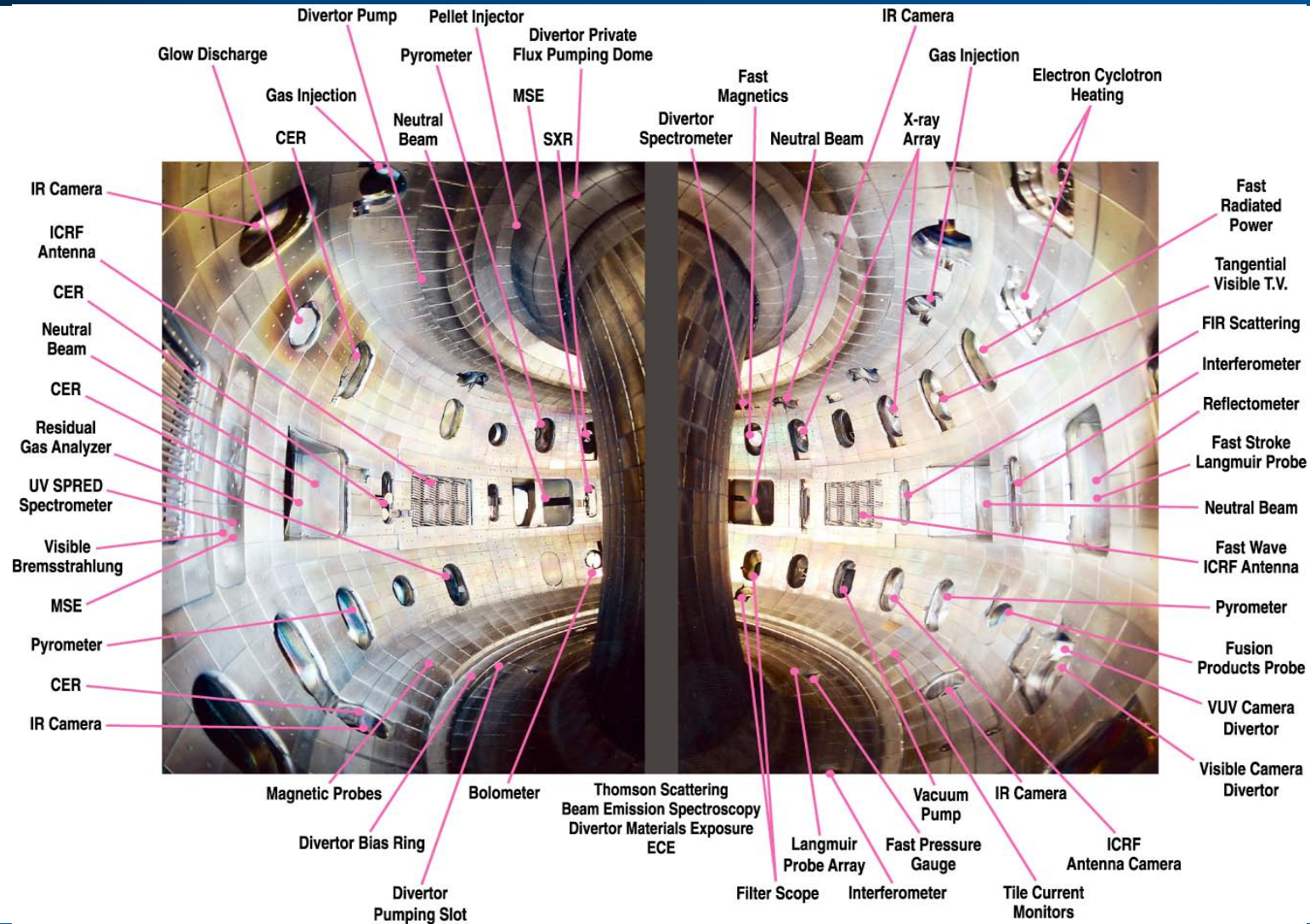
- Comprehensive models
- Architecture for integration
- Computational infrastructure

Experimental Fusion Sciences Places a Large Premium on Rapid Data Analysis in Near-Real-Time

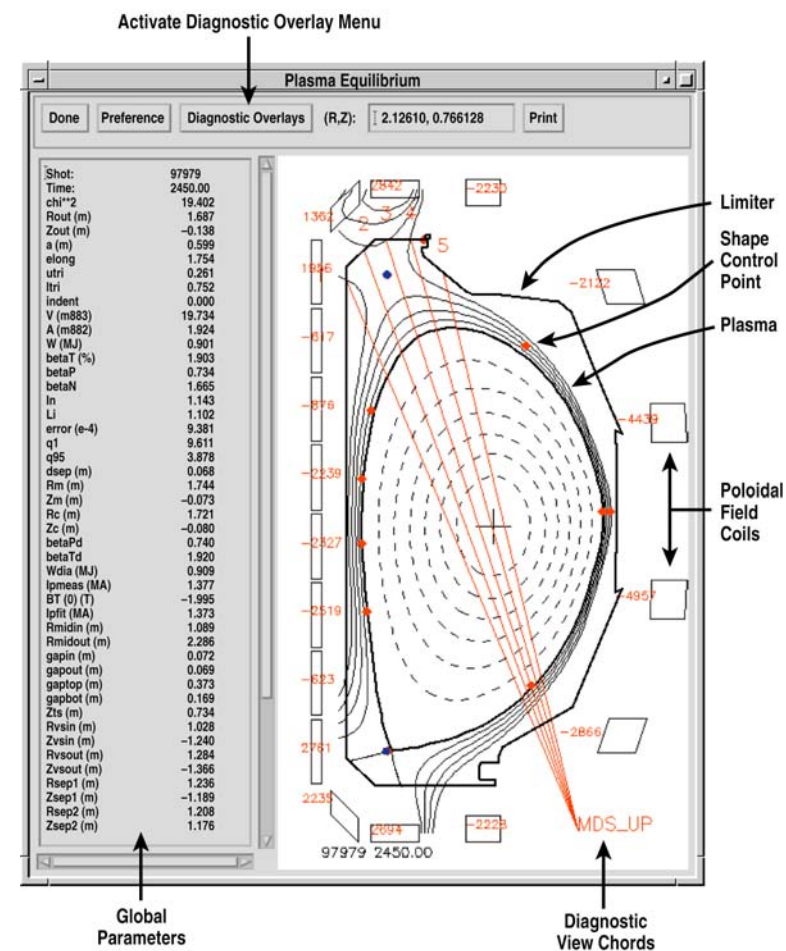
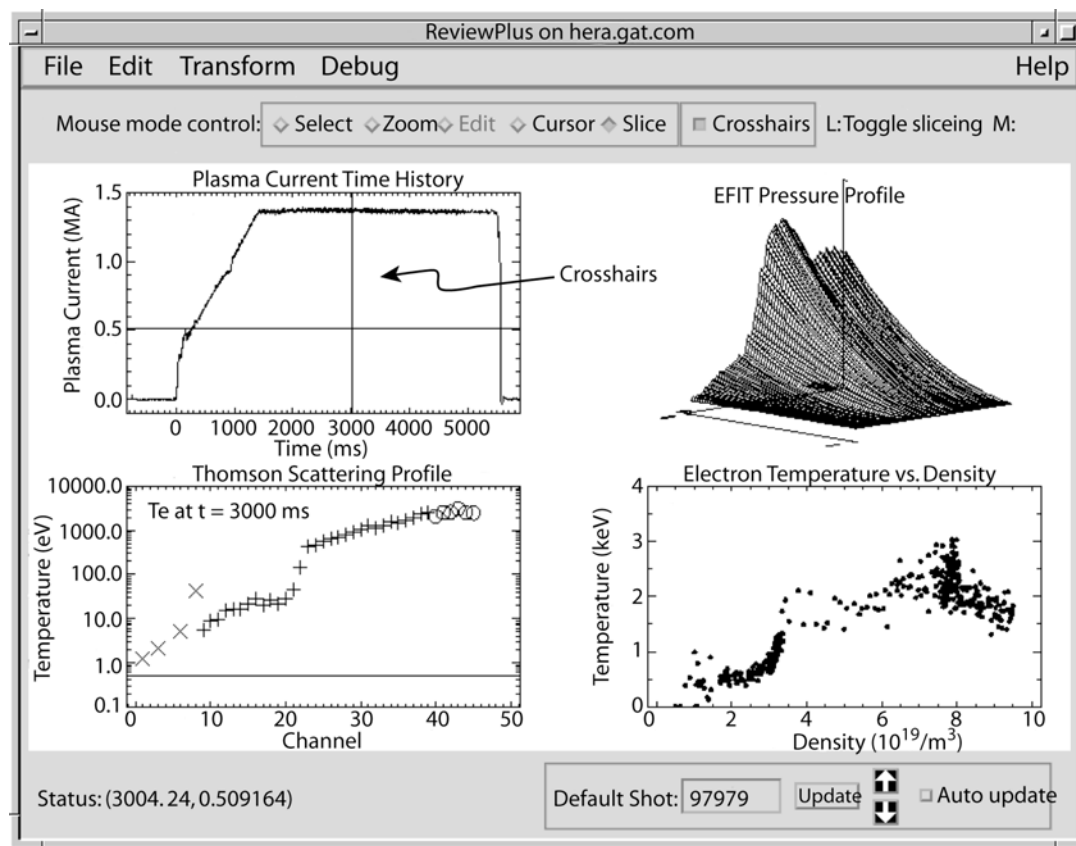


- **Pulsed Experiments**
 - 10s duration plasma every 20 minutes
- **20-40 people in control room**
 - More from remote locations
- **10,000 separate measurements/plasma**
 - kHz to MHz sample rates
 - Between pulse analysis
- **Not batch analysis and not a needle in a haystack problem**
 - Rapid near-real-time analysis of many measurements
- **More informed decisions result in better experiments**
 - The collaborative control room

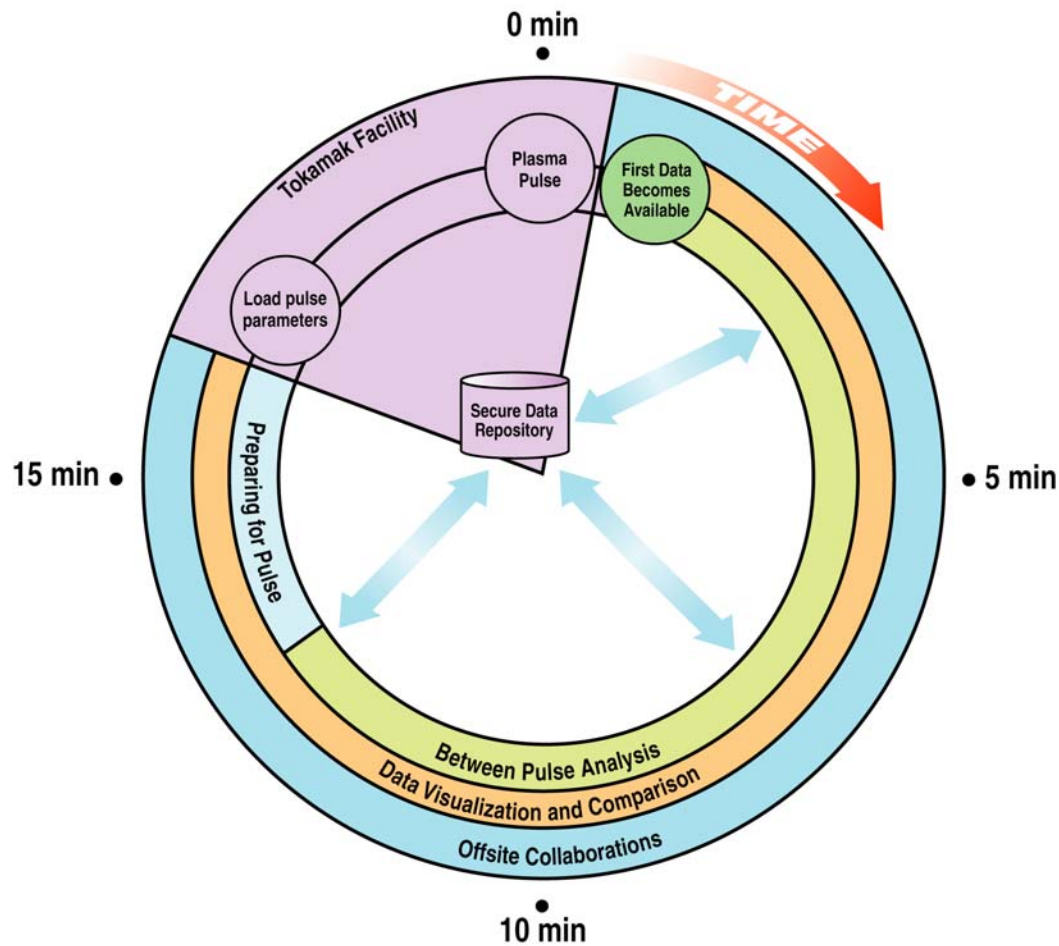
Fusion Tokamaks have Extensive Diagnostics



Custom Applications Allow Detailed Scientific Analysis Between Pulses



Experimental Fusion Science is an Endless Cycle of Analysis and Decision Making

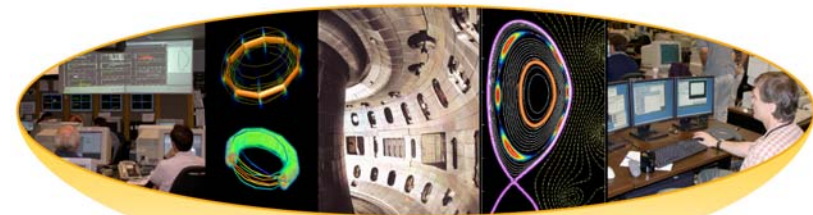


The National Fusion Collaboratory Project (FusionGrid)

- **Funded by the US DOE under the SciDAC Program (2001-2006)**
 - A distributed team: C-Mod, DIII-D, NSTX; ANL, LBL, PCS, Utah
 - Started as a pilot project but has transitioned to production usage
- **Unify distributed MFE research into a U.S. Virtual Organization**

Vision: Optimize the People's Time

- Remote Experimental Operation
- Network Accessible Services (SOA):
Data, Codes, & Visualization
Not CPU cycle scavenging
- Shared Security Infrastructure:
Security with Transparency
Distributed Authorization

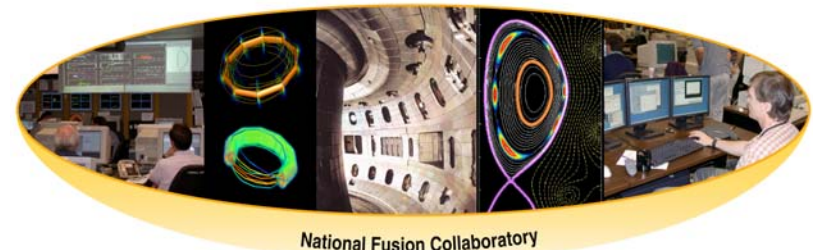


National Fusion Collaboratory



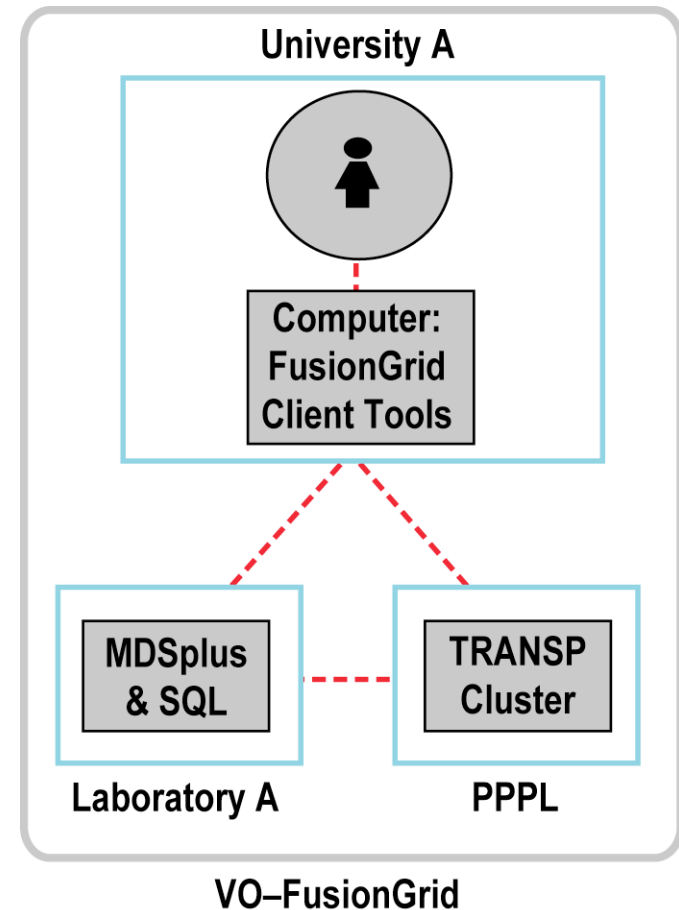
FusionGrid: Unified Security Model with Data Access

- **Authentication: PKI via X.509 certificates**
 - FusionGrid CA & RAs
 - Centralized certificate management
 - Onetime login
- **Authorization: Centralized ROAM**
 - Controlled by resource providers
 - More secure & easier to use
- **Data: Secure via MDSplus**
 - Client-server model
 - Not file transfer



Successful Grid Computing for Fusion Science

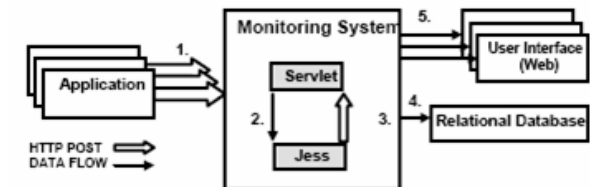
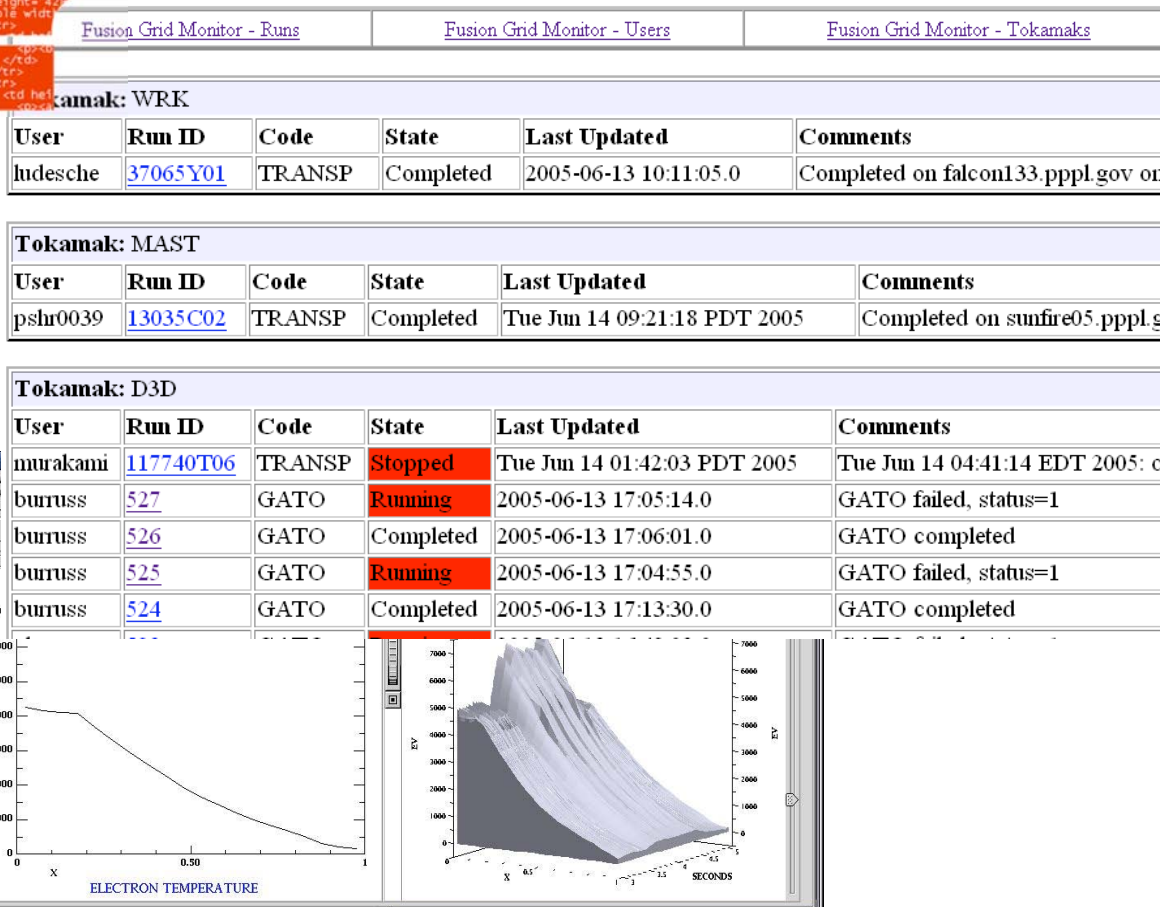
- **The U.S. TRANSP Service**
 - 7,500 cases, 50,000 CPU hours
 - 10 fusion experimental machines
- **Centralized expertise for better support**
 - Debugging, maintenance, monitoring
- **Reduced administrative work at other labs**
 - Smaller sites to use bigger codes
- **Model for other codes**
 - GATO, ONETWO, ELFresco, FWR, GENRAY/CQL3D



FusionGrid Monitoring (FGM) for Scientists



FusionGrid Monitoring – Web client with real-time graphics



- Web browser client
- Java servlet
- Expert system
 - Registered posts
- Relational database

A New Authorization System (ROAM) Deployed

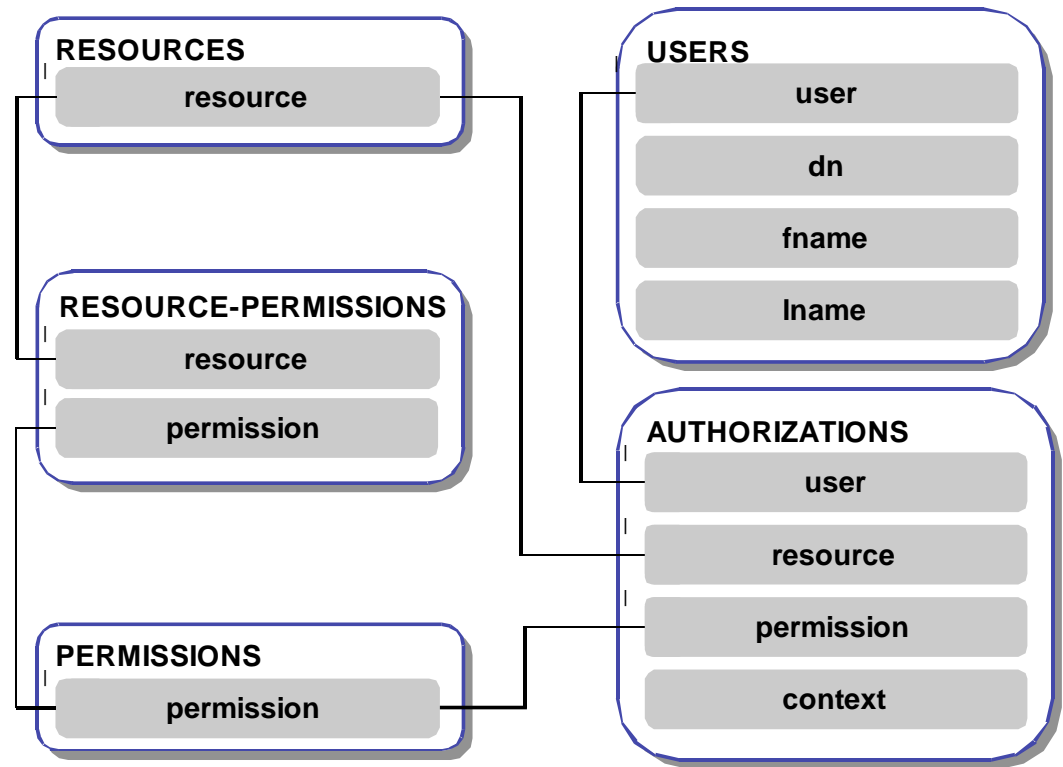
- Resource Oriented Authorization Manager

- Focus on resources

- A resource can be a code, a database, an entire site

- Access via Web client

- Empower stakeholders to specify types of permissions



Access Grid and VRVS Being Used For Communication

Access Grid

- Seminars, working meetings, operations
 - Linux, Windows, & Macintosh OS X
- Operations: collaborative control room
 - Software framework:
sharing humans, data, applications, info

January 2005, DIII-D Tokamak Control Room



May 2004, DIII-D Tokamak Control Room



VRVS

- Web client
 - Small footprint
- Closed source
 - Limits expansion

Electronic Logbook Enhances Collaboration

The screenshot displays two windows from the 'Electronic Logbook' application. The left window, titled 'entry_display - Electronic Logbook - on phobos.gat.com', shows a list of log entries with columns for ID, operator, role, date, and time. The right window, titled 'Logbook - Microsoft Internet Explorer', shows a detailed view of a specific log entry (1050609028) by 'granetz' (PHYSICS_OPERATOR) on 'Jun 09 2005 04:12PM'. The detailed view includes a description of the event (Fizzle, Torus pressure was higher in CHECK state than it has been today. Pre-fill pressure was high on this shot. And the torus pressure alarmed after the shot (gate valves are still being kept closed for 5 minutes after the shot).), a 'Next shot' instruction (reduce pre-fill by 3 ms.), and a 'Recoil' section with a 'Go' button. The bottom of the right window shows 'Results 1 - 81 of 81' and a 'Last updated: 11:28:41A' timestamp.

ID	Operator	Role	Date	Time
115700	nurakani	SESSION_LEADER	Aug 12 2003	4:35:57 PM
115699	nurakani	SESSION_LEADER	Aug 12 2003	4:31:29 PM
115699	greenf	SESSION_LEADER	Aug 8 2003	4:26:43 PM
115698	nurakani	SESSION_LEADER	Aug 12 2003	4:07:39 PM
115698	greenf	SESSION_LEADER	Aug 8 2003	4:26:18 PM
115697	greenf	SESSION_LEADER	Aug 8 2003	4:14:13 PM

- Integrated relational database for rapid navigation and searching
- Accessible worldwide via IDL or web interface
- Live updates when new entries added

Shared Display Walls Installed in Fusion Control Rooms



NSTX



DIII-D

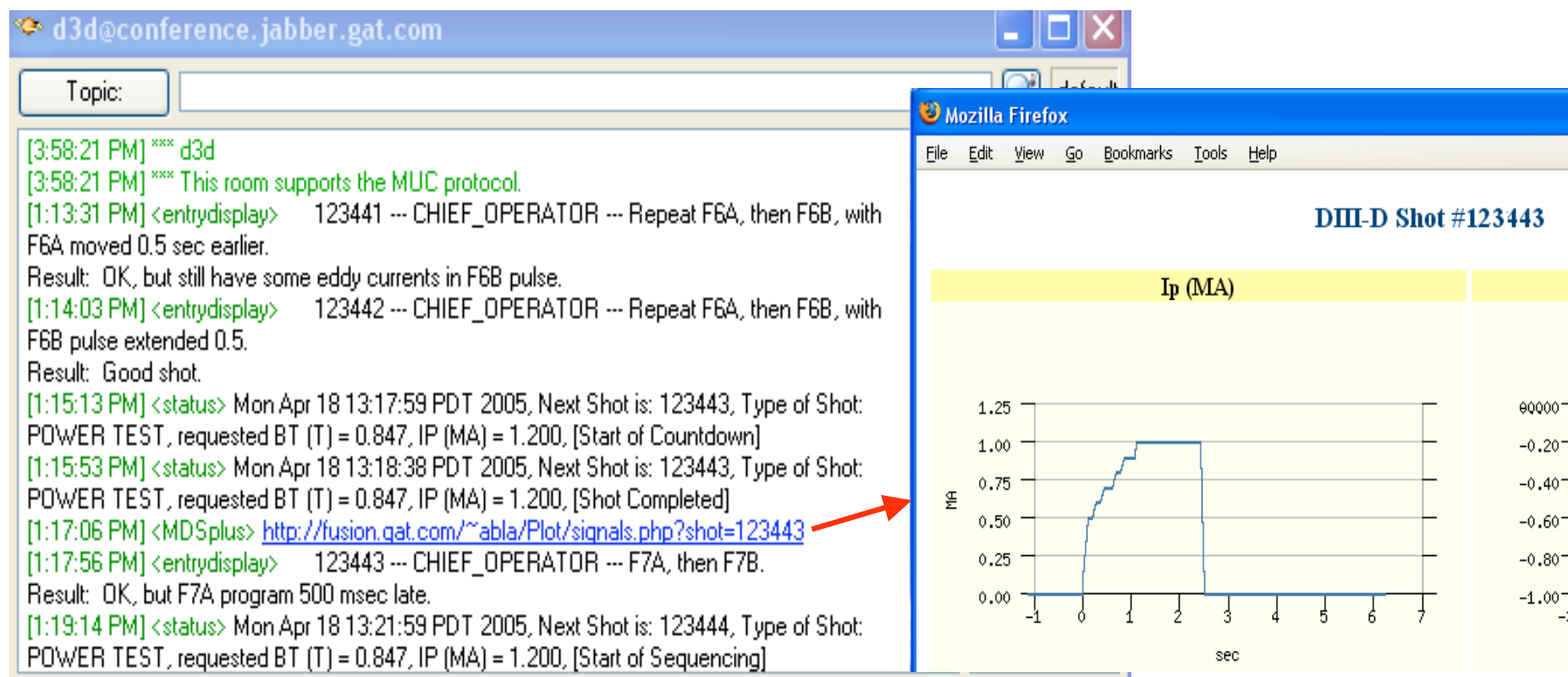


C-Mod

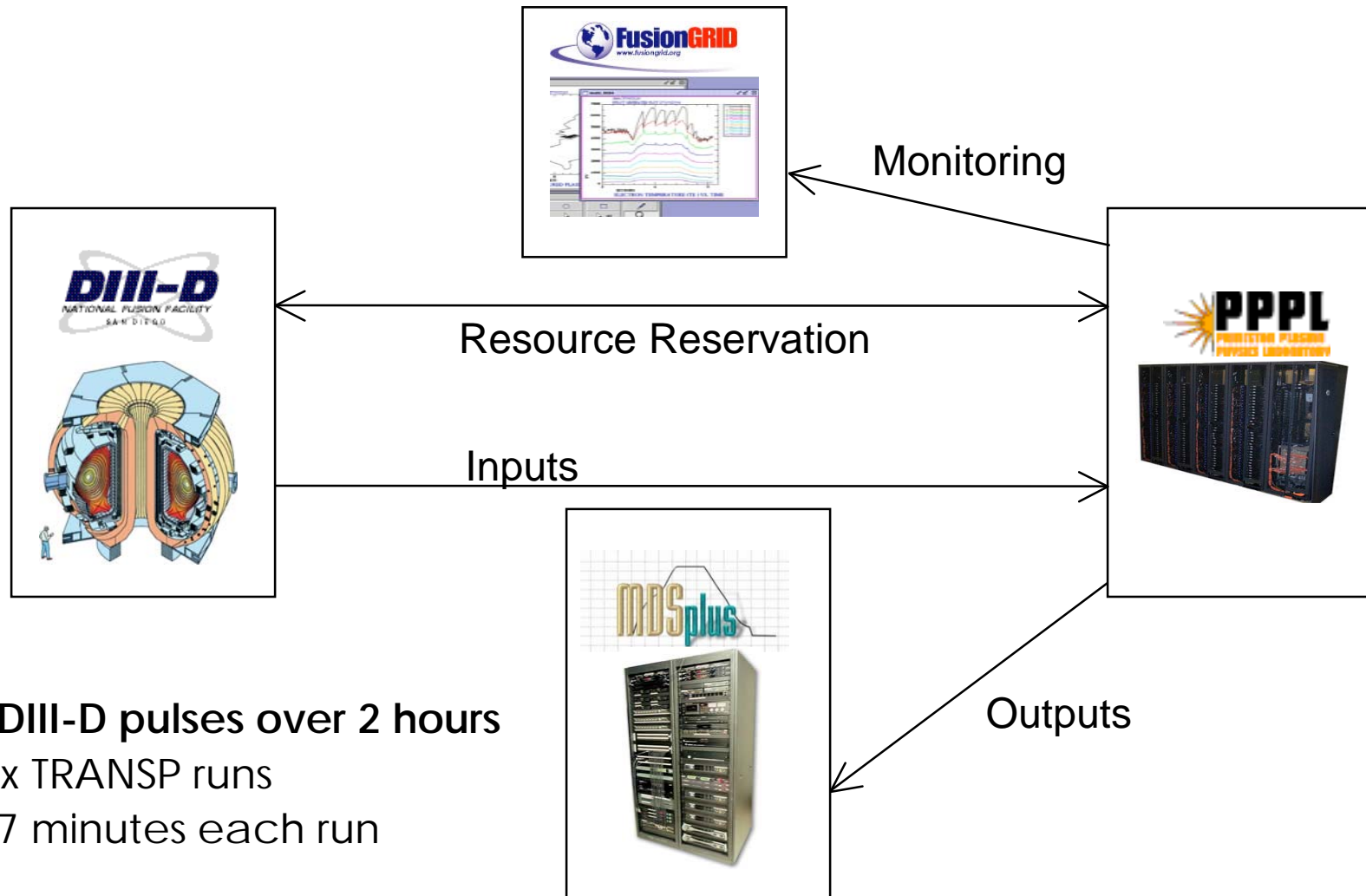
- **Customized Apps**
 - Monitoring
 - Logbook ticker
 - Real-time plots
 - Shape movie
 - AG/VRVS video
- **Sharing to the group**
 - Collocated
- **Sharing from off-site**
 - “See my graph”
 - Web camera

Jabber IM Extended For Small Footprint Collaboration

- The tokamak as a “chat participant”
- Extended to include graphics
- Additional automatic entries: logbook, monitoring software, pulse status

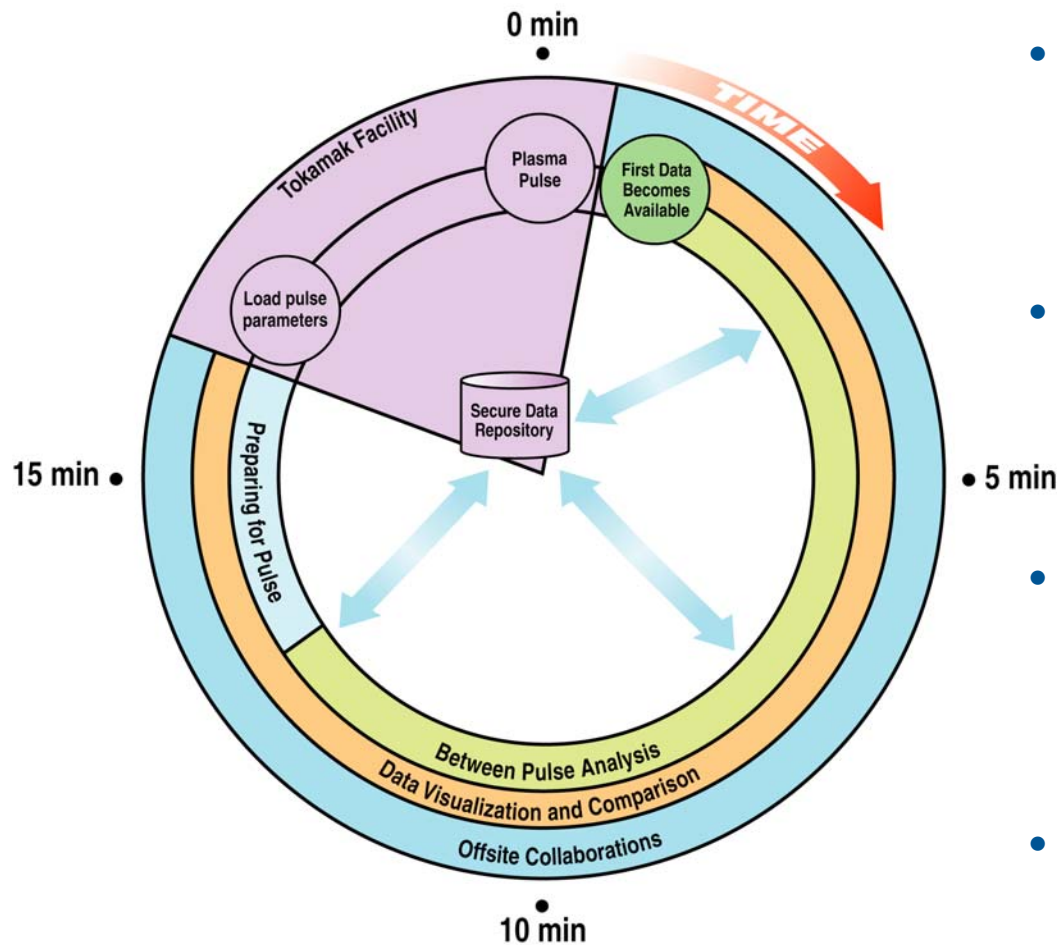


FusionGrid Tested for Between Pulse Data Analysis



- Six DIII-D pulses over 2 hours
 - Six TRANSP runs
 - ~7 minutes each run

Collaborative Control Room: Described Work Is Part of this Critical Concept for ITER



- Secure computational resources scheduled as required
- Rapidly compare experimental data to simulation results
- Share individual results with the group via shared large displays
- Ad hoc/structured communication with integrated data

Concluding Comments

- **The NFC Project has implemented new collaborative technology**
 - Attacking problems defined by fusion scientists
 - FusionGrid services being used to benefit daily FES research
- **Service oriented computation on FusionGrid has proved successful**
 - Optimize the most expensive resource - people's time
- **Clear vision & work scope forward to the Collaborative Control Room**
 - Real-time support for experiments is critical
 - Concept encompasses most if not all FES collaborative needs
 - Clear software enhancements required for success
- **Helps to position US to exploit ITER**